

Thinking Outside the Toilet Tank: Innovation in Urban Water Management
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"Innovation never comes from established institutions. It comes from a graduate student, a crazy person, or someone with great vision."

-Eric Schmidt, Executive Chairman of Google

If this is true, the water community should be pleased that Bill Gates has initiated the "Reinvent the Toilet Challenge."

The Bill & Melinda Gates Foundation gave the California Institute of Technology (Cal Tech) and seven other universities cash grants and implored them to design the toilet of the future. The challenge was to design a safe and affordable, hygienic toilet that uses little water. The toilet was also required to transform waste into energy, clean water and nutrients.

Last month, Cal Tech took first place in the competition and received a \$400,000 grant toward product development, industrial production, and commercialization of their futuristic toilet.

The Cal Tech toilet uses the sun to power an electrochemical reactor that breaks down water and human waste into fertilizer and hydrogen which can be stored in hydrogen fuel cells as energy. The treated water can then be reused for toilet flushing or irrigation.

According to the World Health Organization, 2.5 billion people around the globe are without access to toilets, which often results in the spread of deadly diseases. An estimated 1.5 million children under the age of 5 reportedly die each year from sanitation-related illnesses caused by open defecation. Wealthier nations dedicate a sizeable portion of indoor urban water use to Western-style toilets that require complex, often over-extended sewer systems.

"Many of these innovations will not only revolutionize sanitation in the developing world, but also help transform our dependence on traditional flush toilets in wealthy nations," anticipates Gates. He is hoping that these new toilets will become integrated into society within the next two to four years.

"...we not only must reinvent the toilet, we also must find safe, affordable, and sustainable ways to capture, treat, and recycle human waste," says Sylvia Mathews Burwell, president of the Global Development Program at the Bill & Melinda Gates Foundation. "Most importantly, we must work closely with local communities to develop lasting sanitation solutions that will improve their lives."

And there's the rub: an innovative technology such as the reinvented toilet is only as good as its adaptability to individual, societal and structural conditions.

The first iteration of water saving toilets provided a wealth of complaints as their design required many to double flush even the tiniest of waste loads, defeating the opportunity to save water. The "Low Flush Toilet" three-gallon flusher was re-designed, re-engineered, and replaced with the "Ultra Low Flush Toilet" a 1.6 gallon per flush toilet that succeeded in disposing of all liquids and solids in one flush. The engineering and technology were fine, but it took some time to convince users that double flushes were a thing of the past. The latest "High Efficiency Toilets" at 1.28 gallons per flush don't seem to suffer from the original complaints, but other issues are being raised.

A February 28, 2011 article in SFGate claimed that low-flow toilets were to blame for the increasingly strong whiff rising from San Francisco's sewer systems as more sludge backs up inside the sewer pipes. This claim was loudly refuted by proponents of the water saving devices.

A similar concern was raised again in October 2011 in Colorado as the Legislature rejected a proposal to require new construction projects in the state to require high efficiency toilets.

Representative Keith Swerdfeger said he has no doubts that toilets with 1.28-gallon flush capacities are basically as effective as the 1.6-gallon models that are the present flow limit in Colorado, but he worries that the lower flow would not sufficiently move solid waste through the sewer lines.

"The technology's good, the intent is good, but we also have some unintended consequences below the toilet," Swerdfeger said.

Senator Angela Giron disagreed with this claim. "We have some research that really disputes that," she said.

In fact, the research the senator may be referring to is a 2006 EPA WaterSense publication titled *Appendix A- WaterSense Drainline Carry Testing Results* that documents the effective flush volume of Water Sense certified 1.28 gallon High Efficiency Toilets (HET). These toilets are tested to see that 100 percent of the waste was evacuated: both flushed out of the toilet and transported a suitable distance through the drainline. They are tested with both 'floaters' and 'sinkers.' The results indicated that the HET models tested would succeed in the flush and transport criteria, even under "adverse conditions."

This indicates that WaterSense certified HETs, when installed properly, should not have any problems getting waste through the drainline to the sewer system. The Alliance for Water Efficiency has sponsored a follow-up study by the Plumbing Efficiency Research Coalition on the issue of potential drain line blockages due to commercial HET's. The issue is whether there is enough water to move solid waste where buildings only have toilets and faucets with no other high water uses like clothes washers or kitchens. Results should be in this Fall.

Bringing focus back to the Cal Tech reinvented toilet, it is really more than a toilet in that it includes an on-site mini-wastewater treatment facility. As such, a look at San Diego's experience with their 1998 plan to combine municipally produced recycled water with the potable water source. The "yuck factor" that was generated by the media-coined "toilet to tap" labeling of the recycled water project was a major setback to the program.

Public opposition was so strong that the city council killed the plan. Since then, the San Diego County Water Authority has been working quietly but steadily to change both the details of its plans to use recycled water, and to change public opinion.

According to the newly released San Diego County Water Authority's *2012 Public Opinion Poll Report*, today, 73 percent of the residents of San Diego favor adding recycled water back into the potable water supply. That's an astonishing leap from 2005, when only 28 percent favored re-using water to extend the drinking water supply.

Albeit, the Cal Tech toilet is associated with a small scale water reuse technology, it will face similar challenges as the large scale recycled water projects and small scale graywater systems have faced in California over the past 20 years. The good news is that we can learn from the past and avoid some of the problems previous projects have faced, as we see in the case of San Diego.

The incentive to seek innovative toilet and sanitation system designs is paramount in terms of water use efficiency and public health issues worldwide and here in California. According to EPA's WaterSense program, the toilet alone can use 27 percent of household water in the U.S.

With any innovation, one can expect some resistance: people tend to either embrace change or deny the need for it. And the Western flush toilet is a fixture that has not changed radically in the past 250 years. We maintain an intimate relationship with our toilets. After all, we bare our most private parts to this plumbing edifice every day on a more-or-less regular basis. But change can happen.

Kerry Patterson, author of the book *Change Anything* would advocate that the changes necessary to implement innovations are possible as long as attention is paid to the motivation and abilities of individuals and society, and the underlying structures associated with the technological change.

An example of another innovation funded by the Gates Foundation, the not-for-profit Khan Academy: <http://www.khanacademy.org/>, is changing the way students learn. Its success is already marked by the revolution it is stirring in the field of education, an institution that has resisted change for many years.

Salman Khan, a young hedge fund analyst in Boston began sending on-line math tutorials to his niece Nadia, a seventh grader in New Orleans in 2004. Before long, total strangers began visiting the website, including Bill Gates whose children were benefiting

from the free videos. By 2009, Khan had quit his job, moved to Palo Alto, and began working from his closet in Palo Alto with the mission of providing “free world class education for anyone anywhere.”

In 2010, the Gates Foundation and Google provided \$15 million for the expansion of the Khan Academy website that now counts 4 million visits per month from students in the U.S., 1.7 from India and 1.4 from Australia, as an example.

With over 3000 ten-minute videos in math, and now physics, biology, history and medicine, Khan is able to break down complex subjects into digestible bits of information and knowledge. Khan acknowledges the vital in-person interaction among students and teachers needed for a high quality education. He asserts that the learning modules on the website provide a tool for trained teachers to track each student’s achievements and assist them as they progress at their own speed.

A key component of the Khan Academy is the platform created to track the paths of learning and measure whether the components are working. They gather mass amounts of data from around the world and are able to revise the units as indicated.

The tool is now being piloted in 23 schools, mainly in California classrooms. The Khan Academy has already reached the tipping point where their tool, tracking platform, and ideas have spread dramatically to millions of students over a short period of time.

While innovations in education such as the Khan Academy are not a direct match to innovations in toilet technology, lessons can be learned from such innovation successes as well as others in the water field such as the San Diego County Water Authority’s experience with the introduction of recycled water.

One hopes that the Cal Tech inventors not only invest in the technology and engineering aspects of the reinvented toilet, but also invest time, creativity and resources to:

- consider infrastructure, social, economic, environmental, public health impacts;
- investigate potential pitfalls;
- anticipate and avoid or reduce unintended consequences;
- design an effective social marketing campaign;
- explore the needs and conditions of the communities where the toilets will be introduced to insure acceptance and participation; and
- measure, track, document, and analyze change and results.